

PART A: MULTIPLE CHOICE
Value: 62.5% of the examination

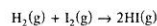
Suggested Time: 80 minutes

INSTRUCTIONS: For each question, select the **best** answer and record your choice on the **Answer Sheet** provided. Using an HB pencil, completely fill in the bubble that has the letter corresponding to your answer.

You have **Examination Booklet Form A**. In the box above #1 on your **Answer Sheet**, fill in the bubble as follows.

Exam Booklet Form/ Cahier d'examen	A	B	C	D	E	F	G	H
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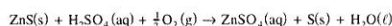
1. Consider the reaction:



Which of the following would decrease the rate of reaction?

- A. an increase in $[\text{I}_2]$
B. a decrease in $[\text{HI}]$
C. a decrease in $[\text{H}_2]$
D. an increase in temperature

2. Consider the reaction:



What would increase the fraction of successful collisions?

I	increasing temperature
II	increasing surface area of ZnS
III	increasing $[\text{H}_2\text{SO}_4]$
IV	adding a suitable catalyst

- A. I and II only
B. I and IV only
C. II and III only
D. I, II, III and IV

3. Consider the following two reactions occurring under the same conditions:

I	$\text{C}_2\text{H}_5\text{Cl}(\text{l}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{HCl}(\text{g})$	$E_a = 254 \text{ kJ}$
II	$\text{C}_2\text{H}_5\text{Br}(\text{l}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{HBr}(\text{g})$	$E_a = 219 \text{ kJ}$

Which of the following is correct?

- A. Reaction I is faster because it has a higher E_a .
B. Reaction II is faster because it has a lower E_a .
C. Reaction I is slower because it is exothermic.
D. Reaction II is slower because it is endothermic.

4. An uncatalyzed reaction has the following values for E_a :

$$E_{a(\text{forward})} = 250 \text{ kJ}$$

$$E_{a(\text{reverse})} = 100 \text{ kJ}$$

If a catalyst is added to the reaction, which of the following values could be correct?

	$E_{a(\text{forward})}$ (kJ)	$E_{a(\text{reverse})}$ (kJ)	$\Delta H_{(\text{forward})}$ (kJ)
A.	50	200	-150
B.	50	200	+150
C.	200	50	-150
D.	200	50	+150

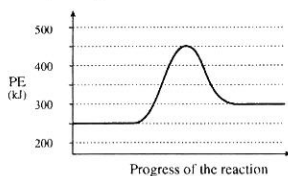
5. Consider the following reaction mechanism:

Step 1:	$\text{C}_2\text{H}_5\text{HgI} \rightarrow \text{C}_2\text{H}_5\text{Hg}^+ + \text{I}^-$
Step 2:	$\text{C}_2\text{H}_5\text{Hg}^+ + \text{Cl}^- \rightarrow \text{Particle 1}$
Overall:	$\text{C}_2\text{H}_5\text{HgI} + \text{Cl}^- \rightarrow \text{C}_2\text{H}_5\text{HgCl} + \text{I}^-$

Identify Particle 1 and a reaction intermediate from the above mechanism.

	Particle 1	Reaction Intermediate
A.	$\text{C}_2\text{H}_5\text{Hg}^+$	$\text{C}_2\text{H}_5\text{HgI}$
B.	$\text{C}_2\text{H}_5\text{HgI}$	$\text{C}_2\text{H}_5\text{Hg}^+$
C.	$\text{C}_2\text{H}_5\text{HgCl}$	I^-
D.	$\text{C}_2\text{H}_5\text{HgCl}$	$\text{C}_2\text{H}_5\text{Hg}^+$

6. Consider the following PE diagram for a reversible reaction:



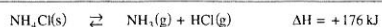
Which of the following correctly corresponds to the diagram above?

	PE of activated complex (kJ)	$E_{a(\text{reverse})}$ (kJ)	$\Delta H_{(\text{forward})}$ (kJ)
A.	150	200	+50
B.	200	150	-50
C.	450	150	+50
D.	450	300	+50

7. Reacting systems naturally tend toward what changes in enthalpy and entropy?

	Change in Enthalpy	Change in Entropy
A.	decreasing	increasing
B.	decreasing	decreasing
C.	increasing	increasing
D.	increasing	decreasing

Use the following equilibrium to answer questions 8 to 10.



8. Which of the following would cause a shift to the right?
- adding NH_4Cl
 - removing NH_3
 - increasing pressure
 - decreasing temperature
9. When HCl is added, how do the concentrations of NH_3 and HCl at the new equilibrium compare to the original equilibrium concentrations?

	$[\text{NH}_3]$	$[\text{HCl}]$
A.	higher	higher
B.	higher	lower
C.	lower	higher
D.	lower	lower

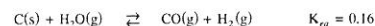
10. Solid NH_4Cl is added to the preceding equilibrium. What will happen to the forward and reverse rates?

	Forward Rate	Reverse Rate
A.	increases	increases
B.	no change	no change
C.	increases	decreases
D.	decreases	increases

11. Due to a change in temperature, a system at equilibrium shifts, causing the concentration of products to change. Which of the following could be correct?

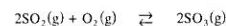
	[Products]	Value of K_{eq}
I	increases	no change
II	increases	increases
III	decreases	decreases
IV	decreases	increases

- I only
 - II only
 - I and IV only
 - II and III only
12. Consider the following equilibrium:



At equilibrium, there are 0.60 mol C, 0.30 mol H_2O and 0.32 mol CO in a 1.0 L flask. What is the equilibrium $[\text{H}_2]$?

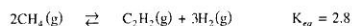
- 0.090 M
 - 0.15 M
 - 3.5 M
 - 5.9 M
13. Consider the equilibrium:



Initially, 1.6 mol SO_2 is placed in a 3.0 L container. At equilibrium, $[\text{O}_2] = 0.15 \text{ M}$. What is the value of K_{eq} ?

- 0.26
- 1.2
- 4.0
- 43

14. Consider the following equilibrium system:



Initially, 0.4 mol of each substance is placed in a 1.0 L container. Which of the following correctly describes this system as it approaches equilibrium?

	$[\text{C}_2\text{H}_2]$	Forward Rate
A.	increases	decreases
B.	increases	increases
C.	decreases	decreases
D.	decreases	increases

15. Which solution will have the greatest electrical conductivity?

- 0.10 M HCl
- 1.0 M LiOH
- 2.0 M H_3PO_4
- 2.0 M $\text{CH}_3\text{CH}_2\text{OH}$

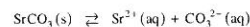
16. What are the ion concentrations that result when 1.0×10^{-3} mol of K_3PO_4 is dissolved to produce 1.00×10^2 L of solution?

	$[\text{K}^+]$	$[\text{PO}_4^{3-}]$
A.	$3.0 \times 10^{-5} \text{ M}$	$1.0 \times 10^{-5} \text{ M}$
B.	$1.0 \times 10^{-5} \text{ M}$	$3.0 \times 10^{-5} \text{ M}$
C.	$7.5 \times 10^{-4} \text{ M}$	$2.5 \times 10^{-4} \text{ M}$
D.	$3.0 \times 10^{-3} \text{ M}$	$1.0 \times 10^{-3} \text{ M}$

17. What happens when equal volumes of 0.2 M Na_2S and 0.2 M CaS are mixed?

- Only Na_2S precipitates.
- Only CaSO_3 precipitates.
- Both CaSO_3 and Na_2S precipitate.
- No precipitate forms.

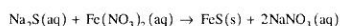
18. Consider the solubility equilibrium:



The addition of which of the following substances will cause the equilibrium to shift right?

- $\text{HCl}(aq)$
- $\text{SrCO}_3(s)$
- $\text{Na}_2\text{CO}_3(aq)$
- $\text{Sr}(\text{NO}_3)_2(aq)$

19. Given the precipitation reaction:



What is the K_{sp} expression for the saturated solution formed?

A. $K_{sp} = \frac{[\text{Fe}^{2+}][\text{S}^{2-}]}{[\text{FeS}]}$

B. $K_{sp} = [\text{Fe}^{2+}][\text{S}^{2-}]$

C. $K_{sp} = \frac{[\text{FeS}]}{[\text{Fe}^{2+}][\text{S}^{2-}]}$

D. $K_{sp} = \frac{1}{[\text{Fe}^{2+}][\text{S}^{2-}]}$

20. What is the K_{sp} for the salt $\text{Pb}(\text{IO}_3)_2$ if its solubility is $5.0 \times 10^{-5} \text{ M}$?

A. 5.0×10^{-13}

B. 1.3×10^{-13}

C. 2.5×10^{-9}

D. 5.0×10^{-5}

21. What is the maximum $[\text{IO}_3^-]$ that can exist in a $6.9 \times 10^{-2} \text{ M Cu}^{2+}$ solution?

A. $2.0 \times 10^{-6} \text{ M}$

B. $1.0 \times 10^{-6} \text{ M}$

C. $1.0 \times 10^{-3} \text{ M}$

D. $6.9 \times 10^{-2} \text{ M}$

22. Which of the following represents the results of tests on an acidic solution?

	Reaction with Mg(s)	Colour with Neutral Red
A.	yes	red
B.	yes	amber
C.	no	red
D.	no	amber

23. Which of the following represents a protonated water molecule?



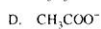
24. Which of the following best describes a weak base?

	K_b	% Ionization
A.	very small	low
B.	very small	high
C.	very large	low
D.	very large	high

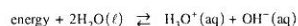
25. Which species will produce the greatest hydroxide ion concentration in solution?



26. Water will react most completely as an acid with



Use the following equilibrium equation to answer questions 27 and 28.



27. What does this equation represent?



B. the ionization of water

C. the ion product of water

D. the equilibrium expression for water

28. Which of the following is correct for water?

	Temperature	pH	Solution Type
A.	increases	increases	neutral
B.	increases	decreases	acidic
C.	increases	decreases	neutral
D.	decreases	increases	basic

29. What is the pH of 0.50 M LiOH?

A. 2.0×10^{-14}

B. -0.30

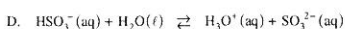
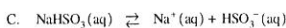
C. 0.30

D. 13.70

30. What is the equilibrium constant expression for the predominant equilibrium in $\text{NaHSO}_3(\text{aq})$?

A. $\frac{[\text{H}_3\text{O}^+][\text{SO}_3^{2-}]}{[\text{HSO}_3^-]}$

B. $\frac{[\text{H}_2\text{SO}_3][\text{OH}^-]}{[\text{HSO}_3^-]}$



31. Which of the following 0.10 M solutions would have the lowest pH?



32. Which of the following describes a solution of $\text{LiClO}_4(\text{aq})$ with respect to hydrolysis?

- A. $\text{Li}^+(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{LiOH}(\text{aq}) + \text{H}^+(\text{aq})$
- B. $\text{LiClO}_4(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{LiOH}(\text{aq}) + \text{HClO}_4(\text{aq})$
- C. $\text{ClO}_4^-(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{HClO}_4(\text{aq}) + \text{OH}^-(\text{aq})$
- D. No hydrolysis reaction occurs.

33. Which of the following is a basic salt solution?

- A. $\text{NH}_3(\text{aq})$
- B. $\text{NH}_4\text{I}(\text{aq})$
- C. $\text{KNO}_3(\text{aq})$
- D. $\text{Na}_2\text{CO}_3(\text{aq})$

34. A chemical indicator typically

- A. changes colour when acid or base is added.
- B. resists changes in pH when acid or base is added.
- C. resists changes in colour when acid or base is added.
- D. neutralizes acids and indicates this with a colour change.

35. A solution was tested with two indicators and the following results were obtained:

Indicator	Colour
methyl red	yellow
thymol blue	yellow

The approximate pH of the solution is

- A. 5.2
- B. 6.0
- C. 9.4
- D. 10.6

36. What is the net ionic equation for the reaction of nitric acid with $\text{NaOH}(\text{aq})$?

- A. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell)$
- B. $\text{HNO}_3(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{H}_2\text{O}(\ell)$
- C. $\text{HNO}_3(\text{aq}) + \text{NaOH}(\text{aq}) + \text{H}_2\text{O}(\ell) \rightarrow \text{NaNO}_3(\text{aq}) + \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$
- D. $\text{H}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) + \text{H}_2\text{O}(\ell)$

37. Consider the following buffer equilibrium system:



What is the net result of adding a small amount of HCl ?

- A. The $[\text{H}_3\text{O}^+]$ increases slightly.
- B. The pH remains the same.
- C. The pH increases slightly.
- D. The $[\text{H}_2\text{CO}_3]$ decreases slightly.

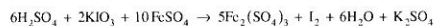
38. An oxide of which of the following elements will form a solution that acts only as a base?

- A. P
- B. N
- C. Zn
- D. Ba

39. An oxidized substance

- A. is the reducing agent and loses electrons.
- B. is the reducing agent and gains electrons.
- C. is the oxidizing agent and loses electrons.
- D. is the oxidizing agent and gains electrons.

40. Consider the following redox equation:



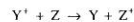
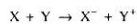
Which species is the reducing agent?

- A. I from KIO_3
- B. S from H_2SO_4
- C. H from H_2SO_4
- D. Fe from FeSO_4

41. What is the oxidation number of C in $\text{NaC}_7\text{H}_5\text{O}_2$?

- A. -4
- B. -2
- C. $-\frac{2}{7}$
- D. +2

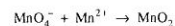
42. Consider the following spontaneous redox equations:



Which of the following describes the relative strengths of the oxidizing agents?

- A. $\text{Z} > \text{Y} > \text{X}^-$
- B. $\text{X}^- > \text{Y} > \text{Z}$
- C. $\text{X} > \text{Y}^+ > \text{Z}^+$
- D. $\text{Z}^+ > \text{Y}^+ > \text{X}$

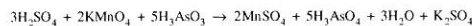
43. Consider the following skeletal redox reaction in basic solution:



Which of the following is the reduction half-reaction?

- A. $2\text{e}^- + 4\text{OH}^- + \text{Mn}^{2+} \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$
- B. $4\text{OH}^- + \text{Mn}^{2+} \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O} + 2\text{e}^-$
- C. $3\text{e}^- + 2\text{H}_2\text{O} + \text{MnO}_4^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$
- D. $4\text{e}^- + 2\text{H}_2\text{O} + \text{MnO}_4^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$

44. Pure H_3AsO_3 solid can be used to standardize a KMnO_4 solution using a redox titration as follows:

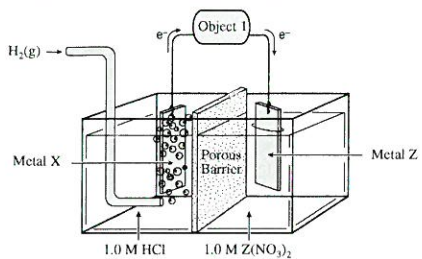


A 0.200 g sample of H_3AsO_3 was titrated with 14.6 mL of KMnO_4 solution.

What is the molarity of the KMnO_4 solution?

- A. 0.0435 M
- B. 0.109 M
- C. 0.272 M
- D. 5.48 M

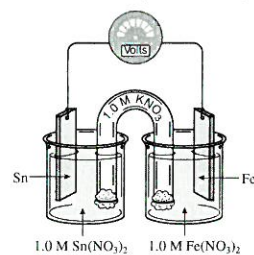
45. Consider the following diagram of a standard electrochemical cell:



Which of the following is correct as the cell operates?

	Object 1	Metal X
A.	voltmeter	anode
B.	voltmeter	cathode
C.	power supply	anode
D.	power supply	cathode

Use the following electrochemical cell diagram to answer questions 46, 47 and 48.



46. What is the cathode half-cell reaction?

- A. $\text{Sn}^{2+} + 2e^- \rightarrow \text{Sn}$
- B. $\text{Fe}^{2+} + 2e^- \rightarrow \text{Fe}$
- C. $\text{Fe}^{2+} + e^- \rightarrow \text{Fe}^{3+}$
- D. $\text{Sn}^{2+} + 2e^- \rightarrow \text{Sn}^{4+}$

47. Which of the following correctly describes the operating cell?

	Direction of Positive Ion Migration	Reducing Agent
A.	towards Sn	Sn
B.	towards Sn	Fe
C.	towards Fe	Sn
D.	towards Fe	Fe

48. What would be observed if the solution in the U-tube was replaced with 1.0 M K_2S , leaving all of the other components the same?

	Sn Half-cell	Fe Half-cell
A.	precipitate	precipitate
B.	precipitate	no precipitate
C.	no precipitate	precipitate
D.	no precipitate	no precipitate

49. An iron pipeline can be protected from rusting by connecting it to a

- A. zinc nitrate solution.
- B. silver nitrate solution.
- C. zinc electrode buried beside the pipeline.
- D. silver electrode buried beside the pipeline.

50. What products result from the electrolysis of molten KBr ?

	Product at the Cathode	Product at the Anode
A.	K	O_2
B.	K	Br_2
C.	O_2	H_2
D.	Br_2	K

You have Examination Booklet Form A. In the box above #1 on your Answer Sheet, ensure you filled in the bubble as follows.

Exam Booklet Form/ Cahier d'examen	A	B	C	D	E	F	G	H
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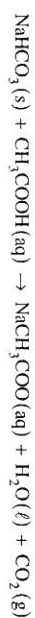
This is the end of the multiple-choice section.
Answer the remaining questions in the Response Booklet.

PART B: WRITTEN RESPONSE
Value: 37.5% of the examination

Suggested Time: 40 minutes

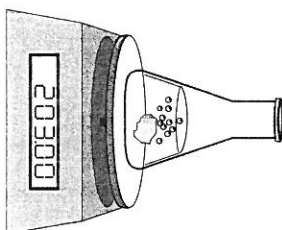
1. (4 marks)

Solid sodium bicarbonate and acetic acid were reacted in an open flask as follows:



The following data was recorded:

Time (s)	Mass of Flask and Contents (g)
0.00	203.00 g
30.0	202.95 g
60.0	202.93 g
90.0	202.92 g



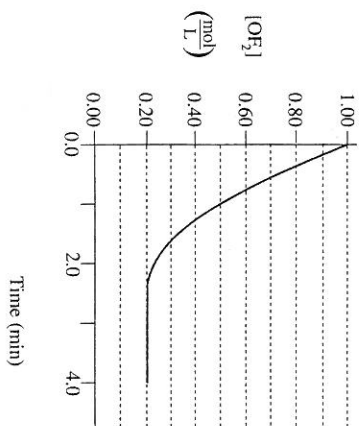
Calculate the overall rate of reaction in grams of NaHCO_3 per minute.

2. (4 marks)

Consider the following equilibrium:



Initially, some OF_2 was placed in a 1.0 L container and allowed to react. The amount of OF_2 was monitored over 4 minutes and the following graph was produced:



Calculate the value of K_{eq} .

3. (4 marks)

Consider the equilibrium for a saturated solution of PbI_2 :



What is the maximum $[\text{Ag}^{+}]$ that can exist in a saturated solution of PbI_2 without causing a precipitate to form?

4. (3 marks)

Complete the following equilibrium, then predict whether the reactants or products will be favoured and explain why.



5. (5 marks)

Calculate the initial concentration of a KF salt solution that has a $\text{pH} = 8.65$.
Begin by writing the equation for the predominant equilibrium reaction.

6. (3 marks)

In three separate trials, 10.00 mL samples of H_2SO_4 were titrated with 0.40 M NaOH and the results are tabulated below:

Trial	Volume of 0.40 M NaOH
1	18.20 mL
2	16.90 mL
3	17.10 mL

Calculate the concentration of the H_2SO_4 .

7. (4 marks)

Balance the following redox equation in basic solution:



8. (3 marks)

A solution of MnSO_4 is electrolyzed using inert electrodes. Write the anode and cathode half-reactions and describe any observations at the cathode.

Anode half-reaction: _____

Cathode half-reaction: _____

Cathode observation: _____

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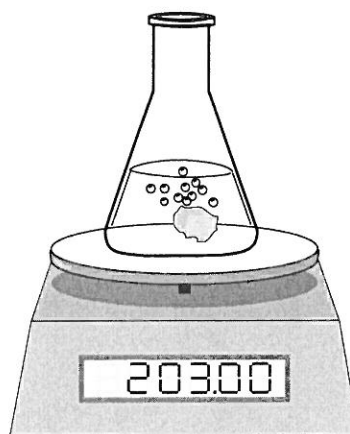
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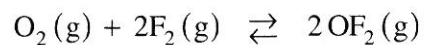
Time (s)	Mass of Flask and Contents (g)
0.00	203.00 g
30.0	202.95 g
60.0	202.93 g
90.0	202.92 g



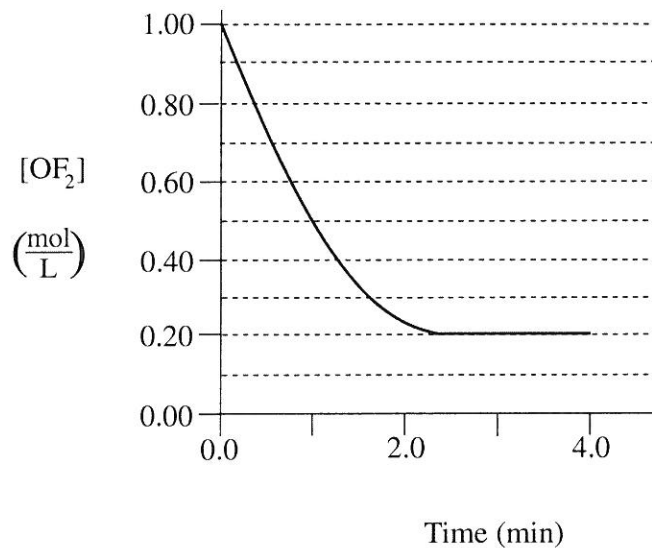
Calculate the overall rate of reaction in grams of NaHCO_3 per minute.

2. (4 marks)

Consider the following equilibrium:



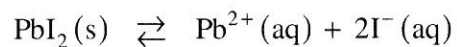
Initially, some OF_2 was placed in a 1.0 L container and allowed to react. The amount of OF_2 was monitored over 4 minutes and the following graph was produced:



Calculate the value of K_{eq} .

3. (4 marks)

Consider the equilibrium for a saturated solution of PbI_2 :



What is the maximum $[\text{Ag}^+]$ that can exist in a saturated solution of PbI_2 without causing a precipitate to form?

4. (3 marks)

Complete the following equilibrium, then predict whether the reactants or products will be favoured and explain why.



5. (5 marks)

Calculate the initial concentration of a KF salt solution that has a $\text{pH} = 8.65$.
Begin by writing the equation for the predominant equilibrium reaction.

6. (3 marks)

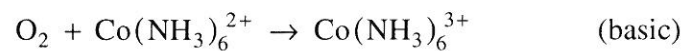
In three separate trials, 10.00 mL samples of H_2SO_4 were titrated with 0.40 M NaOH and the results are tabulated below.

Trial	Volume of 0.40 M NaOH
1	18.20 mL
2	16.90 mL
3	17.10 mL

Calculate the concentration of the H_2SO_4 .

7. (4 marks)

Balance the following redox equation in basic solution:



8. (3 marks)

A solution of MnSO_4 is electrolyzed using inert electrodes. Write the anode and cathode half-reactions and describe any observations at the cathode.

Anode half-reaction: _____

Cathode half-reaction: _____

Cathode observation: _____